

a COMPLAINANT'S EXHIBIT No. 201. James D. Maher,  
Commissioner.

NEW YORK CITY, May 19, 1913.

This certifies that a copy of the within report has been filed in  
the Mayor's office by the Metropolitan Sewerage Commission.

JAMES MATTIHEWS,  
*Executive Secretary.*

*Preliminary Reports on the Disposal of New York's Sewage.*

V.

Study of the Collection and Disposal of the Sewage of the Richmond  
Division.\*

Metropolitan Sewerage Commission of New York.

George A. Soper, James H. Fuertes, H. de B. Parsons, Charles  
Soysmith, Linsly R. Williams, Commissioners.

September, 1912.

1 *Study of the Collection and Disposal of the Sewage of the  
Richmond Division.*

September 1, 1912.

Honorable William J. Gaynor, Mayor of the City of New York:

SIR: This report on the collection and disposal of the sewage of  
the Richmond Division, is the fifth in the series of Preliminary Re-  
ports on the Disposal of New York's Sewage which has been issued  
by this commission with the object of making public at an early  
date its opinion as to the way in which it will be necessary to deal  
with the sewage of the Metropolitan District.

The adoption of the plans here proposed would provide the north-  
ern and northeastern parts of Staten Island, containing all the more  
thickly settled localities and including over eighty per cent. of the  
population of the borough, with main drainage and sewage disposal  
works at moderate cost, and would afford as great a measure of pro-  
tection as a consideration of the condition of the water in the whole  
harbor and of the possibilities of contamination in this locality seem  
to make necessary.

The disposal of the sewage of that part of the Borough of Rich-  
mond not provided for in this report offers little difficulty. That  
part of the territory which is not rural should be provided with local

\* This report is issued in advance of the final report of the Metropolitan  
Sewerage Commission in order that the contents may be of early service. Some  
features of this report will remain open for revision until the final report is  
submitted.

disposal plants of such high efficiency that their effluents can be discharged into the neighboring water courses without danger of causing local offense.

The possibility that a greater degree of protection for the harbor than is proposed in this report may be needed in the distant future has been borne in mind in preparing these plans and, in consequence, the works have been so devised as to be adaptable to a more comprehensive scheme without undue loss of the completed structures.

All the work planned in this report will not be required in the immediate future, but it is regarded as necessary that such main drainage work as is undertaken by the city in this borough shall conform to these plans or such modifications of them as a more detailed study of the local conditions than has been possible by this commission may require.

To a great extent the sewerage plans made by the local authorities have been utilized in preparing the plans of main drainage and disposal described in this report, the object being to aid and supplement the city's efforts in disposing of the sewage in a sanitary manner. In those localities for which the borough has had no definite sewerage plans, it has been necessary to outline the future lateral sewerage districts as seemed most reasonable from the information at hand concerning the proposed locations and grade of streets. By following the same outlines as nearly as may seem best after detailed study, the engineers of the borough will be able to facilitate the final design of the main drainage systems along the lines recommended in this report.

#### General Description of the Territory.

**Location and Area.**—This report deals with that part of Staten Island which slopes toward the Narrows, Upper bay, Kill van Kull and Newark bay, or nearly the whole of the northern and northeastern portions of the Borough of Richmond. This territory includes, besides the natural drainage areas tributary to the bodies of water mentioned, a comparatively small area which drains naturally to Willowbrook, and thence to Fresh Kills and Lower New York bay, and from which it is feasible and desirable to carry the house sewage to the Kill van Kull for final disposal.

The line bounding the district on the south starts from Fort Wadsworth at the Narrows, and runs in a generally westerly direction through Arrochar and Grasmere, across Todt Hill and through the grounds of the Richmond Borough Almshouse, finally reaching the village of New Springville. On the west the boundary line follows closely the Port Richmond Road, passing through Bull's Head and Graniteville, and thence not far from Morningstar Road to a point south of Elm Park, from which point it follows the watershed along the Staten Island Rapid Transit Railroad, westerly nearly to South avenue, whence it runs in a northwesterly direction, crosses Richmond Terrace near Holland avenue, and continues to the shore of Newark bay east of Howland Hook.

Between this line and the established bulkhead line bordering the Narrows, Upper bay, the Kill van Kull and Newark bay, there is included an area of 9,178 acres, or about 14.3 square miles exclusive of cemeteries, parks, institutional property, U. S. Government land, etc. This area is approximately equal to one-fourth of the total land surface of Staten Island.

**Topographical Features.**—The topography of the territory is varied. The part which drains to the northeastern shore of Staten Island is separated from that which drains to the north shore by a high ridge which traverses the island in a general northeasterly and southwesterly direction, and which rises at Todt Hill, on the southern boundary of the territory, to an elevation of 409.8 feet above the Richmond high water datum. The slopes on the easterly side of the ridge, within the limits of the territory, are precipitous. The westerly and northerly slopes are generally gradual.

In the western part of the territory the land is comparatively low, and in many places, near the water courses and shores, it is 3 swampy. The slopes down to these swampy areas are generally gradual, and the ridge marking the outline of the district on the west is not high.

The terminal moraine forms a conspicuous feature of the topography in the southeastern part of the district. Along the boundary line from Arrochar to Grasmere the bare rounded hills and numerous depressions and ponds, characteristic of morainic topography, are especially noticeable.

The land near the shore, from Fort Wadsworth to Howland Hook, is made up alternately of headlands, of varying height, and valleys. Streams flow through many of these valleys, while in others the natural water courses have been replaced by sewers. Much of that portion of the territory which drains to the Kill van Kull lies within the drainage area of Bodine creek, which is the largest water course in the district.

**Population.**—Nearly all the more thickly settled part of Staten Island lies within the drainage districts of the Narrows, Upper bay, Kill van Kull and Newark bay. Out of a total population in the Borough of Richmond, in 1910, of 85,969, this territory contained an estimated population of 64,320, or almost exactly three-fourths of the total. In 1940, it is probable that this area will have no less than 140,000 people out of 190,000, the minimum number that may be expected to inhabit the borough at that date.

While, for a number of years previous to 1905, the growth of population in the borough was slow, due to various causes, since that date the population has increased at a comparatively rapid rate. Owing to changed conditions, it seems reasonable to expect that this rapid growth will continue.

**Development.**—The land which lies near the shore from Rosebank almost to Howland Hook is well populated, and in some places thickly settled, but no part of the whole area has a population closely approaching in density that which exists in most of the other boroughs of New York City. In fact, with the exception of a few centers which are chiefly devoted to business purposes, and a number

of spots where buildings of a poor class are huddled together, the whole area, for a considerable distance back from the waterfront, may be termed suburban. Further from the water, most of the territory is rural in character, and there are large tracts which are still wholly unimproved.

While the populated sections will gradually extend farther and farther from the waterfront, much of the territory to the south and southwest is likely to remain in a rural and unimproved state for many years. It seems certain that the business centers will gradually expand, although nearness to Manhattan will cause activities to be confined mostly to the establishment of stores to supply the needs of the local population. In course of time docks  
4 and warehouses will undoubtedly occupy the Stapleton waterfront, and water and rail facilities make the north shore a superior place for the establishment of factories.

**Sewerage of the Territory.**—During the last few years, large amounts of money have been spent by the borough in the construction of sewers. In the areas which drain to the Narrows and Upper bay, and along the western part of the north shore of the island, much progress has been made in replacing old and shallow village sewers, formerly built to take care of the immediate needs for house drainage, by modern systems. Except in some of the low areas near the waterfront, these new sewers are of the combined type.

In much of New Brighton, and in West Brighton and Port Richmond, the old village sewers have so far remained more or less adequate to the needs of the communities. Few, if any, new combined sewers have been constructed, and little has yet been done concerning the preparation of drainage plans for these areas. The natural water courses which traverse those areas have proved sufficient for the removal of the storm water, and they can continue for some time to perform this service for many places. Certainly, if the storm water in the thickly settled areas near the waterfront is removed by sewers, the run-off from the more sparsely settled upland territory can be adequately provided for in the natural water courses for many years to come.

Wherever new and complete systems of sewers have been installed, the dry-weather flow has been diverted from them, above mean high tide, and carried in a pipe to moderately deep water and the outlet for the storm water has been placed near the shore line. It is the intention of the borough authorities to extend the dry-weather and storm-water outfalls to the pierhead and bulkhead lines, respectively, when the piers and bulkheads are built. By this method of discharging the house sewage into deep water, during dry weather, the shores near the sewer outlets have escaped much of the pollution which otherwise would have been inevitable. Nevertheless it is felt that, at many points, the discharge of house sewage in a crude state, even at the pierhead line, will not be permissible much longer. For this reason an experiment station has been established by means of which the most suitable method of handling the local sewage disposal problem can be studied.

### Separation of the Territory into Subdivisions.

The topography of the whole division is unfavorable for the collection of all the sewage to one central point for disposal. The high ridge separating the areas draining to the northeastern shore of the island from those draining to the north shore, the small areas of low land in the western end of the division, the great distance which it would be necessary to carry much of the sewage and the amount of pumping required are opposed to the collection of the sewage at a point near the Narrows, which is the most favorable place available for its ultimate discharge.

While the discharge of all the house sewage from the northerly and northeasterly slopes of Staten Island into the Narrows would be desirable, and economy of operation would result from having only one disposal plant to maintain, it is believed that the benefits derived would not compensate sufficiently for the cost of carrying the sewage to such a plant. Moreover, it seems certain that the Kill van Kull, with its deep water and swift currents, would provide, for many years, if not for all time, a sufficiently favorable place for discharging the sewage from the areas bordering on Newark bay and the Kill van Kull, after it has been passed through settling tanks.

The territory with which this report deals has been subdivided in such a way as to facilitate the collection of the sewage, to provide for each subdivision a favorable and adequate place for treatment works, and to minimize the amount of pumping necessary. At the same time care has been taken not to divide the territory to such an extent as to cause the establishment of plants too small to be operated economically.

The subdivisions, five in number, have been given names associated with the points chosen for the sites of the respective treatment works. They are named and described as follows:

1. The Quarantine Subdivision comprises the area naturally draining to the Narrows from Fort Wadsworth to the Marine Hospital, Stapleton. The settlements known as Clifton, Rosebank and Fort Wadsworth lie within its boundaries.

2. The Stapleton Subdivision comprises the area naturally draining to the Narrows between the Marine Hospital and St. George, Tompkinsville, Stapleton and Concord lie within this area.

3. The Livingston Subdivision comprises the area naturally draining to Upper New York bay west of St. George, and most of that draining to the Kill van Kull east of a line joining the southerly end of Silver Lake, the corner of Castleton and Bement avenues, and the northerly end of Elm Court, West New Brighton. Sailors' Snug Harbor and the settlements of New Brighton and Livingston are included.

4. The West New Brighton Subdivision comprises, roughly, the area naturally draining to the Kill van Kull between the westerly limit of the Livingston subdivision and Tower Hill, Port 6 Richmond, together with the area draining to Willow brook, east of Port Richmond Road. West New Brighton and Castleton Corners, and parts of Port Richmond, Graniteville, Bull's Head and New Springville are in this subdivision.

5. The Elm Park Subdivision comprises, roughly, the area naturally draining to the Kill van Kull and Newark bay between Tower Hill and Holland avenue. Elm Park and parts of Port Richmond and Mariner's Harbor are within its confines.

The boundaries of the Quarantine, Stapleton and western part of the Elm Park subdivisions, are fixed by the limits of the sewerage districts already outlined by the engineers of the borough; but the boundaries of the Livingston and West New Brighton subdivisions, except where bordering on the Stapleton subdivision, and of the eastern part of Elm Park subdivision, have been placed by this commission as seemed best suited to the main drainage plans to be worked out. The limits agree, however, in a general way, with sewerage districts which have been outlined, but as yet only approximately, by the engineers of the borough.

#### Outline of the Proposed Plan for Main Drainage.

The proposed plan for the Quarantine subdivision provides for the collection of the sewage by a high-level intercepting sewer to the foot of Nautilus street, near the Quarantine Station, where, after passing through coarse screens, grit chambers and fine screens, it will be discharged into the deep water of the Narrows. The sewage from the low land in Clifton will be pumped to the high-level sewer.

In the Stapleton subdivision, the sewage will be collected near the foot of Water street, Stapleton, by high- and low-level sewers, passed through settling tanks, and discharged into the Narrows, off Canal street.

The plan for the Livingston subdivision provides for the collection of the sewage, mostly by high-level sewers, to the waterfront at Kissel avenue, Livingston, where, after being passed through settling tanks, it will be discharged into deep water in the Kill van Kull.

According to the proposed plan, the sewage from the West New Brighton subdivision will be brought, by high- and low-level intercepting sewers, to the waterfront near the garbage incinerator in West New Brighton, passed through settling tanks, and discharged into deep water in the Kill van Kull.

7 In the Elm Park subdivision, the sewage will be collected, by high- and low-level sewers, to the vicinity of Newark avenue and Richmond Terrace, where, after being passed through settling tanks, it will be discharged into deep water in the Kill van Kull.

The sewers will vary from 8 inches to 6 feet 9 inches in diameter, and their total length will be 10.88 miles.

#### Main Drainage Systems.

**Kind of Sewers Proposed.**—The collecting and intercepting sewers, as planned for the five subdivisions, are designed primarily to carry eventually only the dry-weather flow from the contributing sewers, already built or to be built, in these subdivisions. Attention has been directed to the fact that the sewers built by the borough have

been, in general, of the combined type, and that future construction is planned along the same lines. This means that during wet weather much of the house sewage, mixed with varying volumes of storm water, will continue to the bulkhead line without being intercepted, and will there be discharged. The growth of population to be expected in the borough has so influenced the design of the proposed dry-weather trunk sewers that many of them will assist materially, for a considerable period, in the disposal of the storm water.

While it would be inadvisable, in those districts that have already been sewerized by the borough authorities, to provide systems of separate sewers, using those already built to remove storm water, this commission considers it desirable, from now on, to construct sewers on the separate plan, and provide only such storm-water sewers as are demanded from time to time. Relieved of an admixture of house sewage, it is likely that many of these storm sewers might empty directly, for many years to come, into the natural water courses which flow northerly into the Kill van Kull. The building of the comparatively small sewers required for the house drainage, and only such storm-water sewers as are absolutely needed, would minimize the cost of sewer construction, a consideration of much weight, especially in view of the fact that the population which can be assessed is small. Among other advantages which the separate system would possess may be mentioned better protection against pollution to the water near shore during wet weather and less quantity of sewage to be handled in the treatment works.

The plans here proposed have been worked out on the assumption that the present policy of constructing combined sewers will be continued, but whether or not this policy is followed in the areas to be sewerized in future, the principal features of the main drainage systems and of the treatment works would be the same. If the sewers were built on the separate system, however, connecting chambers, overflows, tide-gates, and perhaps grit chambers, would be unnecessary, and the costs would be reduced to that extent.

**Population and Quantity of Sewage.**—The sizes to be provided for the main trunk sewers for collecting the dry-weather flow in localities similar in position and condition to the settlements on the northern and northeastern shores of Staten Island should not depend, as has been the case in many cities, upon an estimate of population at any definite period, but upon densities of population on the tributary drainage areas which are considered probable when the areas shall have reached approximately their ultimate development.

The part of Staten Island included within this division is so near Manhattan, and there are so many other reasons, including the possibility of rapid transit, which may greatly accelerate the growth of population in any part of or throughout the district that it would be unwise to restrict the capacities of the proposed trunk sewers to suit what now appears to be the needs of the district thirty years hence. The total construction cost of the sewers as designed will not be a very large sum, and the saving effected by cutting down

their capacities materially would not be as great as might be supposed.

In order to estimate the necessary capacities of treatment works, pumping equipment and other parts of the main drainage works that can easily be added to at later periods, it is essential that estimates be made of present populations and sewage flows. The following table presents these figures as estimated for the various subdivisions for the year 1910, based on United States Census figures. The areas of the subdivisions are calculated to the established bulkhead line, but do not include cemeteries, parks, Sailors' Snug Harbor, U. S. Government property, etc. The "area sewered" column of the table has no reference to the actual area in each subdivision that was provided with sewers in 1910, but the figures represent roughly the areas that were fairly well settled and might with reason be provided with sewers. The populations estimated for these sewerized areas are the ones which have been used as a basis for estimating the flow of house sewage. It will be noticed that in the low-level areas the whole population was assumed to be served by sewers. The total sewage flow, manifestly, is not the average daily amount of sewage that was discharged from the sewer outlets of the district during dry weather, in 1910, but the figures represent a rough estimate of the average amount that might have been expected under a more complete development of the sewerage systems.

Here, as throughout this report, the average flow of house sewage has been assumed to be 125 gallons per inhabitant per day,  
9 and the average ground-water leakage has been taken at  
500,000 gallons per square mile per day, irrespective of local conditions.

#### *Population and Sewage Flow of the Five Sub-divisions in 1910.*

##### 1.—High Level Territory.

Sub-division.	Area, acres.	Area sewered, acres.	Population.	Population on sewerized area,	House sewage mgd.*	Ground water leakage mgd.*	Total sewage flow mgd.*
Quarantine .....	661	330	6,057	5,500	0.69	0.26	0.95
Stapleton .....	1,532	600	16,152	15,000	1.40	0.47	1.87
Livingston .....	893	600	11,183	10,000	0.93	0.47	1.40
W. New Brighton...	4,735	600	12,400	10,000	0.93	0.47	1.40
Elm Park.....	173	140	3,580	3,500	0.33	0.11	0.44
Totals.....	7,994	2,270	49,381	44,000	4.10	1.78	5.88

\* Million gallons per day of 24 hours.

##### 2.—High Level Territory.

Quarantine .....	156	80	1,404	1,404	0.13	0.06	0.19
Stapleton .....	182	110	3,241	3,241	0.30	0.09	0.39
Livingston .....	66	35	250	250	0.03	0.03	0.06
W. New Brighton...	321	240	5,082	5,082	0.47	0.19	0.66
Elm Park.....	459	280	4,962	4,962	0.46	0.22	0.68
Totals.....	1,184	745	14,939	14,939	1.39	0.59	1.98

*Total Population and Sewage Flow of the Five Sub-divisions in 1910.*

Sub-division	Area, acres.	Area sewer'd, acres.	Population.	Population on sewer'd area.	House sewage mgd.*	Ground water leakage mgd.*	Total sewage flow mgd.*
Quarantine .....	817	410	7,461	6,904	0.64	0.32	0.96
Stapleton .....	1,714	710	19,393	18,241	1.70	0.56	2.26
Livingston .....	959	635	11,433	10,250	0.96	0.50	1.46
W. New Brighton...	5,056	840	17,491	15,082	1.40	0.66	2.06
Elm Park.....	632	420	8,542	8,462	0.79	0.33	1.12
Totals.....	9,178	3,015	64,320	58,939	5.40	2.37	7.86

\* Million gallons per day of 24 hours.

10 The following table gives the densities of population, total population and average sewage flow used in designing the sewers of each subdivision. All the territory is assumed to be sewer'd. The area as far as the bulkhead line has been assumed to be populated. Much of the ground near the water will be occupied by industrial establishments instead of dwellings, but sufficient allowance for the sewage flow from these has probably been made by assuming the area populated throughout.

*Total Population and Sewage Flow used in Designing the Proposed Sewers.*

Sub-division.	Density of population per acre.	Population			Aver. sewage flow mgd.*		
		High level.	Low level.	Total.	High level	Low level.	Total.
Quarantine .....	75 -100	52,870	15,600	68,470	7.12	2.08	9.20
Stapleton .....	70½-150	112,385	19,870	132,255	15.24	2.63	17.87
Livingston .....	75 -100	81,975	6,600	88,575	10.94	0.88	11.82
W. New Brighton.	40½-120	247,960	38,260	286,220	34.00	5.04	39.73
Elm Park.....	80 -120	18,040	40,060	58,100	2.39	5.37	7.76
Whole District....	40 -150	513,230	120,390	633,620	70.38	16.00	86.38

\* Million gallons per day of 24 hours.

† Average density on 1,116 acres.

‡ Average density on 1,814 acres. Average density of 50 on 1,283 acres.

Collecting Sewers for the Quarantine Subdivision.—Most of the sewage of the Quarantine subdivision will be collected at the foot of Nautilus street by a high-level intercepting sewer which will intercept the dry-weather flow from the combined sewer in Maple avenue at the corner of Anderson street and pass through Anderson street, Chestnut avenue, New York avenue, Sylvaton terrace and Bay street, and along the shore to Nautilus street. On its route, it will receive the flow from all the territory lying south and west of its course.

The sewage from the low land in Clifton will be collected at the corner of Bay street and Maple avenue by an intercepting sewer in Bay street which will intercept the dry-weather flow from existing sewers in Norwood avenue and Simonson avenue. At Bay street the dry-weather flow from the Maple avenue sewer will be diverted, and together with the flow from the Bay street intercepting sewer will be

led into an automatic, electrically-operated pumping station to be located at this corner. From this pumping station, the sewage will be pumped through a force main in Bay street to the high-level intercepting sewer at the corner of Bay street and Sylvaton terrace.

11 The dry-weather flow from the existing Nautilus street sewer, which drains a large area, will be intercepted and carried by a short connecting sewer to a junction with the high-level sewer above mentioned. The plan also contemplates the construction of a small high-level sewer in Centre street which will intercept the dry-weather flow from the combined sewer at the corner of Norwood avenue and discharge it at Simpson avenue, or a short distance north of it, into the combined sewer planned for Centre street. It will thence be carried to the Maple avenue sewer and finally into the high-level sewers in Anderson street.

The proposed collecting sewers in the Quarantine subdivision vary from 12 inches to 3 feet 3 inches in diameter. Their total length, including the force main, but exclusive of the outlet pipe, is 1.46 miles.

Collecting Sewers for the Stapleton Subdivision.—A large part of the area included within the Stapleton subdivision is at a sufficient elevation to permit its sewage to be collected and passed by gravity through tanks located at Stapleton, but the elevations of the streets in the vicinity of the works are so slight that the sewage from the high-level districts will have to be carried to the works in long conduit submerged below the hydraulic gradient.

On the north, the dry-weather flow from the Arietta street sewer will be intercepted at Stuyvesant place and brought, together with sewage collected on its route, by a high-level sewer passing through Stuyvesant place, Griffin, Hannah, Sarah Ann, Van Duzer and Elizabeth streets to a point a short distance east of Van Duzer street, from which place it will be carried to the treatment works, located on Front street between Prospect street and Water street, by a siphon passing through Elizabeth street, rights of way and Front street.

On the south, the dry-weather flow from the large sewer in Board street will be intercepted at the corner of Canal and Board streets and carried to the treatment works by a siphon passing through Canal, Water and Front streets. From the corner of Riker and Broad streets, a connection will be laid in such a way as to join the large Broad street sewer just above the point at which its dry-weather flow is intercepted.

At Wright and Beach streets, this siphon will have connections through which the dry-weather flow from the existing sewers in these streets will be added. Ample head for this purpose can be secured without making these cutoff sewers of great length.

That part of the sewage of the subdivision which cannot be passed through the treatment works by gravity will be brought to an automatic, electrically-operated pumping station located at the works. Here the sewage will be raised by the pumps to such an elevation as to allow it to pass through the tanks.

12 The two low-level intercepting sewers required will be built in Front street and will be short. The one from the north

will start, until its extension is required, by intercepting the dry-weather flow from the existing Elizabeth street sewer; the one from the south will intercept the dry-weather flow outlet sewer at present in Canal street, and will be joined by the existing 15-inch sewer in Water street. It is assumed that the 10-inch sewer in Thompson street, which now creates foul conditions by discharging into the dock, will be joined to the sewer in Canal street and the flow thus taken to the treatment works.

In designing the high level siphons, the available head was found so small that the velocities through the siphons would have to be less than desirable. They would be especially small for a number of years. Trouble from this cause can be obviated by constructing bypasses from these siphons to the suction well of the pumping station at the treatment works. By means of these by-passes, the siphons can be easily and effectively flushed.

It was found best to make the south siphon of a capacity sufficient to take care of the needs for only a few years with the idea that one or two more conduits can be constructed as required. With the north siphon, conditions were somewhat different. It will be economical to provide this siphon with the same capacity as that of the intercepting sewer leading to it. In order to make the velocity of sewage as great as possible when the flow is small, the north siphon will consist of two pipes of different sizes, the larger one to come into use automatically when the level of the sewage in the high-level sewer reaches a certain height.

Both the north siphon, of 24-inch and 18-inch pipes, and the south siphon, of 24-inch pipe, could it is thought, be built economically and properly of vitrified pipe, with bituminous joints and surrounded by concrete, and the estimates have been based upon this type of construction.

The proposed collecting sewers in the Stapleton subdivision vary from 15 inches to 2 feet 9 inches in diameter. Their total length, including siphons, but exclusive of outlet pipe, is 1.54 miles.

**Collecting Sewers for the Livingston Subdivision.**—Practically all the sewage of the Livingston subdivision can be brought to the treatment works at the foot of Kissel avenue and passed through them by gravity.

The sewage from St. George and New Brighton will be collected by a high-level intercepting sewer which will start at the corner of Jay and Wall streets and pass through Jay street and Richmond terrace to the treatment works.

From the south a high-level sewer will start at the corner of Kissel avenue and Brighton Boulevard and pass through Kissel and 12 Bergen avenues and Health place to the treatment works.

A branch of this sewer will be constructed in Bergen avenue between Oakland avenue and Health place.

A small low-level intercepting sewer will be built in Richmond terrace from Oakland avenue to a small, automatic, electrically-operated pumping station located at the site of the treatment works.

In this subdivision the high-level sewers will have to pass through low land before reaching the treatment works. The street grades

in these low areas have been at least tentatively established. However, the area is not yet built up and it will be feasible to raise the projected street grades wherever necessary, so as to give a light, but sufficient cover over the top of the sewers.

The proposed collecting sewers in the Livingston subdivision vary from 10 inches to 3 feet 3 inches in diameter. Their total length, exclusive of outlet pipe, is 2.77 miles.

**Collecting Sewers for the West New Brighton Subdivision.**—The sewage of the West New Brighton subdivision will be collected by two high-level and two low-level sewers. Just before reaching the treatment works, which are to be located south of Starin avenue, between Rodine and Dongan streets, the sewers join so as to form one high-level and one low-level sewer.

The east high-level intercepting sewer will start at the corner of Elm court and Henderson avenue and pass through Henderson avenue, Water street and Richmond terrace to a junction with the west high-level intercepting sewer.

The west, or perhaps better, the south-high-level intercepting sewer, has been assumed, for the purposes of this report, to start at the proposed Northfield boulevard. Its route will be through Linne street, Madison avenue, Jewett avenue, Roberts street, Manor road, Castleton and Columbia avenues, Cedar and Rodine streets and Richmond terrace, and thence through the city's property at the West Brighton garbage incinerator. A small branch of this sewer will be built in Palmer avenue east from Heberton avenue, so as to intercept the sewage flow from the high area west of the latter street.

The east low-level intercepting sewer will start at the foot of Broadway, at which point it is assumed that the flow from the combined sewers in the low area in the vicinity will collect, and will pass through Richmond terrace and Starin avenue to Dongan street, where it will join with the west low-level intercepting sewer.

The sewage from a large part of Port Richmond and the low area in the vicinity of Rodine creek and Palmer's run will be brought to an automatic, electrically-operated pumping station at the treatment works by the west low-level intercepting sewer which

14 will start in Richmond avenue north of Richmond terrace and pass through Richmond terrace, Starin avenue and Dongan street.

Whether the large undeveloped areas in the West New Brighton subdivision, which lie south of the proposed Northfield boulevard, are finally sewerized upon the separate or upon the combined plan, all the dry-weather sewage flow can be brought by gravity to the upper end of the west high-level intercepting sewer as proposed.

On account of the large population which eventually will occupy the extensive area tributary to it, this sewer is much larger than any of the collecting sewers in the other subdivisions, and can serve for many years to carry to the waterfront much of the storm-water brought to it by the combined sewers in West New Brighton. The surplus storm-water would be led to a trunk sewer which would also collect the flow from the sewers of the low-level district. It is suggested that this trunk sewer be designed of a size sufficient to care for the ultimate

dry-weather flow of the low-level district tributary to it, together with only such storm water as it would probably have to carry for a few years, with the idea that later, when it becomes necessary to close up the water courses and provide artificial channels for the storm-water from the large and now undeveloped areas, a large storm-water sewer can be built to the waterfront.

The conditions in much of this subdivision, with its numerous open water-courses, are such that great economy would result from the construction of sewers on the separate system. It will be particularly desirable, when the time arrives, to sewer on the separate system that portion of this subdivision which lies south of Richmond turnpike and drains directly to Willow brook. When it becomes no longer possible to provide for the storm-water from this area on the surface, it should be emptied into Fresh Kills instead of being carried with the house sewage all the way to the Kill van Kull.

In all the subdivisions, it has been assumed that streets would be opened and graded according to the plans at present outlined by the borough. In this subdivision particularly, the routes of many of the proposed sewers are laid out in streets which are not yet opened.

Owing to topographical conditions in the different subdivisions, the high-level sewers, near their entrance to the various treatment works, have had to be placed lower with reference to the ordinary sewage level in the settling tanks than is desirable. With the small amount of sewage that will be carried through these sewers in dry weather for some time after their construction, small velocities will occur in their lower ends. This will cause trouble from deposits only for a short distance, if at all, in any of the sewers except the west

high-level sewer of the West New Brighton subdivision, as all of them except the one named are small in size and their grades are considerable. While the dry-weather flow is small it might be practicable to run the tanks with a somewhat lower sewage level than that for which they are designed. Opportunity for creating a greater velocity at intervals might be afforded by a temporary lowering of the water level in the tanks or by providing a by-pass to the pumping stations, outfall pipes, or to storm or combined sewers at a lower level.

The proposed collecting sewers in the West New Brighton subdivision vary from 8 inches to 6 feet 9 inches in diameter. Their total length, exclusive of the outlet pipe, is 3.14 miles.

*Collecting Sewers for the Elm Park Subdivision.*—In the four subdivisions already considered, it has been found practicable to collect and dispose of most of the sewage by gravity. Conditions in the Elm Park subdivision are different, resulting in the necessity of pumping considerably more than half the sewage.

A high-level intercepting sewer will start at the corner of Lafayette avenue and Harrison avenue, Port Richmond, to which point it is assumed that a combined sewer in Elizabeth street and Harrison avenue will bring sewage from points as far east as Broadway. The route of the high-level sewer will be through Harrison, Nicholas and Charles avenues, Douglas street and Newark avenue to the treatment works at the corner of Newark avenue and Richmond terrace.

A short branch of this sewer in Roselle and Monroe streets, as far as the railroad, will bring to it the dry-weather flow from existing sewers in Monroe and Cedar streets.

From the east, the sewage from the low-level district will be brought to an automatic, electrically-operated pumping station at the treatment works by a sewer in Richmond terrace starting at Nicholas avenue. From the west, the sewage will be carried to the pumping station by a sewer in Richmond terrace. This sewer will intercept the dry-weather flow from the existing combined trunk sewers in Harbor road, Union avenue and Housman avenue.

The proposed collecting sewers in the Elm Park subdivisions vary from 8 inches to 3 feet in diameter. Their total length, exclusive of the outlet pipe, is 1.97 miles.

**Pumping Stations.**—All the pumping stations in the division will be of the automatic, electrically-operated type. The current for operating them can be purchased, or it might be furnished by the garbage incineration plants at West New Brighton and Clifton, thus affording a desirable outlet for some of the surplus power generated at those plants. This surplus power would undoubtedly be used at

the West New Brighton sewage pumping station, as there 16 would be no expense for transmission at this point. It

would also probably pay to transmit power from the Clifton incinerator to the Maple avenue pumping station in the Quarantine subdivision. Whether it would be economical to transmit power from the West New Brighton incinerator to the Elm Park and Livingston pumping stations, and from the Clifton incinerator to the Stapleton pumping station, would depend upon the price for which current could be purchased from the light and power company.

All the pumping equipment ultimately necessary in these stations would not be required at first. However, all pumps and motors should be in duplicate.

The following table gives the average total head pumped against, the estimated average sewage flow which would have arrived at each pumping station in 1910 under the assumptions given in the discussion of population and sewage flow, the average sewage flow at each station which was used as a basis for estimating the cost of operation, and the aggregate average sewage flow which the sewers leading to the station were designed.

Average sewage flow—Mgd.\*

Pumping station.	Total head, feet.	Estimated for 1910.	Basis for cost of operation.	Contributing sewers designed for.
Maple Avenue....	10.0	0.19	0.50	2.08
Stapleton .....	12.0	0.39	1.00	2.63
Livingston .....	14.0	0.06	0.25	0.88
W. New Brighton..	13.5	0.66	2.00	5.04
Elm Park.....	14.5	0.68	2.00	5.37
All Stations.....	....	1.98	5.75	16.00

\* Million gallons per day of 24 hours.

Outlets.—All the outlet pipes through which the effluent from the various treatment works will be discharged will extend into deep water where the currents are swift.

In the Quarantine subdivision, it is proposed to make use of an existing 20-inch cast-iron outlet sewer which extends out to a point about 225 feet from the present shore line. This pipe will be of sufficient capacity to last for many years, and it should be extended to, or nearly to, the pierhead line. When necessary, another outlet pipe can be added.

There is at present a 3-foot wood stave pipe running to the outer end of the municipal ferry pier at the foot of Canal street, Stapleton, through which pipe the dry-weather flow from the tributary sewers is carried to deep water. This pipe is of sufficient size to carry the effluent from the proposed Stapleton treatment works for many years, and could be made of use. When the pier is extended to the established pierhead line, the outlet pipe should be extended also. When necessary, another outlet can be built at the foot of Prospect street.

From the Livingston treatment works, it is proposed to lay a submerged 24-inch cast-iron pipe to deep water beyond the pierhead line and, when necessary, another outlet pipe can be laid.

Although greatly increased capacity of outlets from the West New Brighton treatment works will ultimately be needed, a 3-foot pipe will be ample in size for a long time. It would probably be practicable to lay a wood-stave pipe under the existing pier at the foot of Bodine street and to extend the outlet for some distance into deeper water by means of a submerged cast-iron pipe.

From the Elm Park treatment works, it is proposed to lay a submerged 20-inch cast-iron pipe into deep water at a considerable distance beyond the pier-head line. This pipe will be of sufficient size to last for a number of years. It can be supplemented by another pipe when greater capacity becomes necessary.

#### Treatment Works.

Forms of Treatment Proposed.—The form of treatment proposed for the sewage is coarse screening and sedimentation, and is the same for all the subdivisions except the Quarantine. A period of from two to three hours should be allowed for settlement. It is believed that the deep water and strong currents along the shores of this district will afford ample opportunity for the diffusion and digestion of sewage in such quantities as may be expected from this portion of Staten Island, if it is treated in the manner proposed, and discharged from submerged outlets into water of 30 feet or more in depth and good current.

The successful protection of the water along these shores will, however, depend somewhat upon the measures taken elsewhere for the betterment of the harbor. The present pollution along the northern, and particularly the northeastern, shore of Staten Island is, to some extent, due to the condition of the harbor water in general.

Passage through grit basins, coarse and fine screens is the form of treatment proposed for the Quarantine subdivision, as the opportunity for diffusion and digestion of the sewage by the harbor waters is here especially favorable.

At the treatment works for all the subdivisions, grit chambers with a settling period of from one to two minutes, will be provided. Where screening is to be used, the grit chamber will prevent heavy deposits which might occur in the outlet pipes or on the harbor bottom near the points of discharge. Where settling tanks are to be used, the grit chambers will guard against trouble that would occur from the deposition of heavy solids in the tanks which are intended for the sedimentation of organic matters.

Sites for Treatment Works.—Many factors have affected the choice of sites for treatment works in the various subdivisions. Among the chief considerations have been the existence of undeveloped land of sufficient area for plants of the size which will ultimately be necessary, the location of these areas at such points as may be best suited to an economical collection of the sewage, this collection being accomplished, as far as possible, without the use of pumping machinery, proximity to any serviceable sewage outlet that might occur, and favorable location with respect to railroad facilities.

At the foot of Nautilus street, there is ample room for locating a screen and for the Quarantine subdivision.

The best site for the location of settling tanks for the Stapleton subdivision seems to be on the west side of Front street between Water and Prospect streets. This location is contiguous to the railroad, and the greater part of the site is occupied by an old asphalt plant and storage yard which is out of use and for sale. On the Water street front there are a few old tenements. By a judicious arrangement of tanks, it will be possible on the area available to treat all the sewage that is likely to reach this point. If, for any reason, the purchase of this land is deemed inadvisable, there are other unoccupied sites in the immediate neighborhood which probably could be obtained.

The proposed site for the Livingston treatment works is west of Kissel avenue between Richmond terrace, as it is to be re-located, and Livingston place. There may be opposition to the establishment of treatment works here, but it is the logical place for them and, if the tanks are properly operated, no offense should be created.

The best site for treatment works in the West New Brighton subdivision is near the garbage incinerator. Economy of operation should result from their location at this point. The block bounded by Starin avenue, Dongan street, Richmond terrace and Bodine street, seems to afford the best site for the works and has therefore been selected. There probably will be plenty of room within this area, even without including the lots bordering on Richmond terrace, to treat any volume of sewage which needs to be collected at this point.

In the Elm Park subdivision, the most favorable site seems to be

at the east corner of Richmond terrace and Newark avenue, although there is a considerable amount of unoccupied land in the vicinity. A location much farther to the west would be inadvisable, if for no other reason than on account of unfavorable conditions which exist there for the discharge of sewage.

19 Capacities of Treatment Works.—In designing the treatment works, sufficient capacity should be provided to take care of the volume of sewage to be expected for a reasonable period in the future. Nevertheless, the tank capacity to be provided in the first installation should not exceed the economical limit, as units can be added when necessary.

The following table gives the estimated average daily amount of sewage which might have been brought to the various works had they been in existence in 1910, and also the capacities which were used as a basis for estimates of cost of construction and operation and which are deemed reasonable as capacities to be provided for in the first installations.

Sub-division.	Average sewage flow—Mgd.*	
	Estimated for 1910.	Treatment works, first installation.
Quarantine .....	0.96	3.0
Stapleton .....	2.26	6.0
Livingston .....	1.46	4.0
W. New Brighton.....	2.06	6.0
Elm Park.....	1.12	3.0
All Sub-divisions.....	7.86	22.0

\* Million gallons per day of 24 hours.

Disposal of Sludge.—The sludge produced in this division may be disposed of in various ways. For many years the amount of sludge will be comparatively small. In 1910, the digested sludge from two-story settling tank installations in the four subdivisions for which they are proposed might have amounted to 18 tons a day. When the capacities of the first tank installations are reached, the amount of sludge will probably be about 38 tons a day.

The treatment works in the district are so placed that the sludge can be transported by water or rail. It would be possible, therefore, to dispose of it either at sea or on land. The presence of two garbage incinerators, both almost directly on railroad lines, would make it feasible to burn the sludge and garbage together. Centrifugal dryers might be placed at each disposal plant to dry the 20 sludge before transportation, or it might be more economical to install such dryers at one or both incinerators and transport the larger volume of wet sludge to the incinerators in proper cars.

There is a large amount of waste land along the railroad line in the northwestern part of the island, near Arthur Kill, which would be suitable for filling with the dried sludge from the settling tanks,

If the sludge were transported hither without previous drying, it would probably be necessary to establish drying beds near the railroad before the sludge could be made available for filling purposes.

If the sludge is to be disposed of at sea, it would be advisable to collect it at one or two points, to avoid construction of piers and loss of time in the operation of sludge steamers. For the purposes of this report, it has been assumed that all the sludge would be delivered wet into tanks located at the Stapleton treatment works, from which tanks a sludge discharge pipe would run out on the municipal pier. By this plan no new piers would have to be built and the sludge steamers passing out of the harbor from other treatment works would have to deviate only slightly from their course to serve as carriers for the Staten Island sludge.

#### Cost of Main Drainage Works.

The estimated costs of the main drainage works proposed in this report, not being based on detail designs, are necessarily of a preliminary nature.

The following tables give a concise summary of the estimated cost of construction and of the annual charges for maintenance and operation. The costs of land and rights of way are not included.

## Estimated Cost of Construction.

Sub-division.	Sewers,	Pumping stations.	Outfall pipes.	Grit chambers.	Treatment works.	Total without Engin'g, etc.	Total engineering & continuing expenses, 15%,	Total Costs.
Quarantine .....	\$38,325*	8,000	6,400	.....	\$8,000†	63,225	19,075	83,220
Stapleton .....	62,430†	10,000	3,000	33,500	63,000	141,530	21,290	163,220
Livingston .....	84,995	6,000	12,400	9,750	42,000	148,995	22,915	170,310
W. New Brighton .....	164,395	12,000	17,400	3,500	63,000	290,295	31,030	269,275
Ellin Park .....	62,125	12,000	13,500	2,000	31,500	121,125	18,170	139,295
Whole District, . . . . .	\$412,080	48,000	52,500	11,500	207,500	731,580	109,740	841,320

## 21 Estimated Annual Cost of Maintenance and Operation.

Sub-division.	Annual cost of maintenance and operation.		
	Without fixed charges.	Fixed charges.	Total.
Quarantine .....	\$3,820	3,505	7,325
Stapleton .....	5,127	8,260	13,387
Livingston .....	4,694	8,618	13,312
W. New Brighton .....	7,584	15,142	22,726
Elm Park .....	5,742	7,048	12,790
Whole District .....	\$26,967	42,573	69,540

\* Including Force Mains.

† Including Siphons.

‡ Grit and Screen Chamber.

(Here follows map of proposed sewer-disposal project for Borough of Richmond.)

